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ABSTRACT

A growing concern is that our nation is failing to provide a technology infrastructure for K-12 education that will enable graduates to compete in the information-based economy of the 21st century. The Living Textbook project is designed to deliver real-time, multimedia information on demand for use in classroom instruction. Three pilot schools in upstate New York and three in New York City have been linked by a wide area network with technology housed at Syracuse University's Northeast Parallel Architectures Center (NPAC). This paper outlines the project's view of a high-performance-computing-and-communications (HPCC) approach to delivering information on demand. It discusses trends in the capacity and speed of HPCC while also describing specific NPAC technologies like InfoMall, a state-funded program enabling technology transfer, and InfoVision, a suite of client/server information-on-demand applications. Short-term goals for the Living Textbook project include a video library searchable and available on-line, an interactive multimedia journey through New York State geography, telemedicine linking rural health care facilities with university hospital specialists, and related educational applications. (BEW)

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The Living Textbook: A Demonstration OF Information on Demand Technologies in Education

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The Living Textbook: A Demonstration of Information on Demand Technologies in Education

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Abstract

This paper describes trends in high-performance computing and communications favoring information based applications and "education on demand." NPAC's InfoMall model of technology transfer, small business partnerships, and collaborative software development is used to develop an innovative set of educational applications that include: video on demand, New York State–The Interactive Journey, Collaboration technology in education, and a set of text, speech, and simulation based education software packages.

Author's note: The figures illustrating the concepts described in this paper were originally produced with screen capture software and converted to GIF as part of our on-line information system. These figures cannot be scaled to the required 3 1/4 inch width nor can they be converted to PICT format and retain reasonable image quality. Please see paper SCCS # 647 The Living Textbook in

http://www.npac.syr.edu/pub/by_index/sccs/papers/index.html.

The Living Textbook Project

As a National Information Infrastructure (NII) evolves to link schools, libraries, homes, and offices with high-speed digital networks, will K-12 schools be prepared to take advantage of communications, computing, and software technologies that are currently available only to research universities, scientific laboratories, and large corporations? As our society moves into the information age, will high school graduates be capable of performing in a high-technology workplace? A growing concern is that our nation is failing to provide a technology infrastructure for K-12 education that will enable our graduates to compete in the information based economy of the next century.

The Living Textbook project is designed to deliver real-time, multimedia, information on demand for use in classroom instruction in six K-12 pilot schools. We are in the first month of a multi-year project. Our task in the first year is to demonstrate a glimpse of the future where schools will be connected to the NII, and have access to terabytes of multimedia information sources stored on centralized digital information servers. This project is funded through support of the New York State Governor's Office and the New York State Science and Technology Foundation, and corporate support from NYNEX.

Our project is centered on NYNEX's NYNET, a regional ATM (asynchronous transfer mode) gigabit commercial network. The Living Textbook project is among the first in the nation to link K-12 schools to an ATM wide area network infrastructure. NYNET connects three K-12 schools in the Syracuse-Rome area of upstate New York, and three schools in New York City with state of the art parallel computers, databases, and large scale digital storage facilities at the Northeast Parallel Architectures Center (NPAC) at Syracuse University.

Our project team includes computational scientists from NPAC, education researchers from Syracuse University School of Education, and Columbia Teachers College, and teacher teams from the six pilot schools. The four major components of our project include:

- developing multimedia educational applications and tools based on high-speed computing and communications networks
- developing pilot demonstration projects in six New York State high schools or middle schools
- creating the educational and technical support for teachers to implement new high-technology based instructional applications
- assessing the educational effectiveness of these new instructional applications.

This paper outlines our view of a technological approach needed to deliver information on demand to the classroom using state of the art high-performance computing and communications technologies. Development of teacher teams,

collaboration between educators, learners, and computational scientists, software development for the classroom, and assessment are essential components of this project but are not described in this technological overview.

The upcoming sections of this paper are as follows: section 2 of this paper describes trends in high-performance computing and communications technologies; section 3 describes InfoMall, NPAC's technology transfer program and how it is used in the Living Textbook project; section 4 describes InfoVision–NPAC's suite of information on demand applications and technologies, the Living Textbook is an example of InfoVision in education; section 5 describes the initial set of information on demand applications to be delivered in year one of the Living Textbook project; section 6 summarizes the technological approach we plan in the first year of the Living Textbook project.

Trends in HPCC

Three important developments in the high-performance computing and communications (HPCC) community motivate and support this innovative application of technology in education. First, a thousand fold increase in compute power has been achieved over the past decade. Second, a shift in emphasis from Grand Challenge scientific applications to National Challenge societal applications of HPCC technologies has occurred at the federal policy level. Third and most recently, a thousand fold increase in telecommunications performance has occurred, matching the growth in available compute power. Together, these changes open new opportunities for collaboration between computational scientists and the education community. New HPCC applications include educational uses of scientific simulations, delivering video on demand to the classroom, and developing the concept of "education on demand" by linking K-12 classrooms to digital services on the NII.

Trends in computing performance on the largest over the past three decades are measured in megaflops (million floating point operations per second) in the 1970s, gigaflops (billion operations per second) in the 1980s, and the teraflop (trillion operations per second) in the 1990s. A one-thousand fold improvement in computing performance has been achieved over the past ten years. Parallel computers have won out over sequential, vector based supercomputers as the highest performance computers. Now, all computers are becoming parallel computers. For example, by 1995, we expect to see 100 megaflop video game controllers in the home entertainment market produced by alliances of video game and computer vendors. This next generation of home computer/home entertainment system will be based on parallel processing. This level of compute performance was a supercomputer only five years ago.

The President's High-Performance Computing and Communications Initiative of 1991 was the driving force behind the development of high performance computing. The initial focus of the HPCC program was to support the science missions of federal agencies such as NASA, the National Science Foundation, the Department of Energy, and the Advanced Research Projects Agency. Global warming, the human genome project, and molecular modeling are examples of scientific "Grand Challenges." More recently, the Clinton administration identified a set of "National Challenges" intended to more directly benefit society in general, and prepare our nation for the development of an information superhighway and the coming of an information age in U.S. industry. The "National Challenges" target the development of a civil information infrastructure, digital libraries, education, energy management, environment, health care, manufacturing, national security, and public access to government information.

The past few years has brought a thousand fold increase in the performance of telecommunications technologies. The NII promises to deliver approximately 10 megabits per second to all homes, businesses, and schools, a one thousand fold improvement in performance over currently available 10 kilobit per second modem connections. This development in communications technology promises to enable many new business opportunities, community databases, and large scale digital information services for schools.

In New York State, plans to develop an upstate supercomputing corridor between Syracuse, Rome, and Ithaca was developed over 1991-1992. NYNEX then began to build a wide-band, high-speed telecommunications link between the upstate participants of the Supercomputing Corridor at Syracuse University, Cornell University, and The U.S. Air Force Rome Laboratory. The first public demonstration of NYNET was performed in October, 1993 in a public meeting of the Congressional Committee on Space, Science, and Technology at Rome Laboratory. A recent demonstration of multimedia information on demand over NYNET was performed for First Lady Hillary Clinton during her visit to Syracuse University in April, 1994.

The NYNET ATM gigabit network now links Rome, Syracuse, and Ithaca in upstate New York, and several sites (SUNY Stony Brook, Grumman, Brookhaven National Laboratory, Cold Springs Harbor Laboratory, Polytechnic University, Columbia University, and NYNEX Science and Technology Laboratory) in down state New York (Figure 1).

The first six schools participating in the Living Textbook Project have direct links to NYNET, these schools include Fowler High School in Syracuse, N.Y., Rome Free Academy in Rome, N.Y., Whitesboro Middle School in Whitesboro, N.Y., and The School of the Physical City, The Dalton School, and Public School 126 in New York City.

InfoMall Model

InfoMall is NPAC's program for technology transfer of HPCC technologies to industry, small business, the community, and education [4]. InfoMall is funded by New York State and consists of over 50 members; one third large businesses, one third small businesses, and one third university, government, and community organizations (Fox et al., 1993).

InfoMall is designed to provide "one stop shopping" for information technologies, technical expertise, business support, and links among virtual corporations. InfoMall is based on the analogy of a retail shopping mall providing consumers easy access to a broad range of consumer goods and services (Figure 2). The components of InfoMall include:

- *InfoTech* which gathers, evaluates, and integrates the best available HPCC research technologies, and deposits them in

the *InfoWare* warehouse

- *InfoTeam* software teams made up of small businesses or small groups inside large corporations which integrate and develop new software products
- *InfoMarket* which links software developers and consumers. InfoMall includes HPCC vendor organizations, market organizations providing computer services, consulting, and system integration
- InfoMall stores provide essential services and infrastructure such as training and consulting, HPCC facility testbeds to prototype and deploy new software products, and business support.

The Living Textbook project will deliver multimedia applications in a high performance computing and communications environment. Following the InfoMall model of HPCC application development, the Living Textbook project exploits the New York State Supercomputing Corridor, the NYNET gigabit network, as well as many related technologies such as high end personal computers, web browsing software tools, and digital video technologies.

This project requires our team to collect, integrate, evaluate, and develop systems of core enabling HPCC technologies for information analysis, access, and dissemination. These core enabling technologies will include parallel databases, mass storage, integration software, ATM network protocols, compression, parallel rendering, collaboration services, image processing, and three-dimensional geographic information systems.

InfoMall is based on small business partnerships, and the Living Textbook employs this same model of technology development through partnerships with WorldView Information Technology Corporation of Cortland, New York, and ReFlex I/O and TravelVenture of Syracuse, New York.

WorldView will provide three-dimensional authoring software to support a network distributed, interactive journey of New York State (described below). This partnership with WorldView allows our project team to dramatically speed up the software development cycle and deliver a product in the course of weeks rather than months. WorldView will work with NPAC to link via NYNET a sophisticated user interface (redesigned for kids) running in the classroom with parallel databases, and parallel rendering engines at NPAC.

ReFlex I/O of Syracuse, New York is a computer animation company developing sophisticated special effects for commercial advertising and movies. ReFlex will work with NPAC to develop a classroom interface to The Living Textbook Project built on top of standard web technologies .

TravelVenture is a small business startup developing World Wide Web accessible travel services. TravelVenture will provide the Living Textbook project with tourist and travel information and images for use in the journey of New York State.

Additional partners of NPAC and the Living Textbook project currently include NYNEX, the U.S. Air Force Rome Laboratory, AskERIC, The Center for Analysis and Prediction of Storms at the University of Oklahoma, the Onondaga County Public Library, and Syracuse Language Systems.

InfoVision Technologies and Applications

Deployment of the NII depends in large part on private industry investment to connect the approximately 100 million end users to the major trunk lines. Many observers expect that partnerships will evolve from the media, entertainment, telephone, cable communications, computing, and the video game industries to provide the first digital information services. The initial applications are likely to be movies on demand, customized news services, and interactive television. These applications represent large markets (e.g., the video game industry is approximately $25 billion per year), and if successful, could justify the capital investment required to build the NII. Once in place, the NII could then be exploited to deliver innovative information processing intensive applications in business, research, and education.

In a 1990-1993 survey, we identified information processing as the most promising opportunity for applying HPCC technologies in industry (Fox, 1992). In a classification of information processing applications, we identified four important classes: information production (e.g., simulation), information analysis (e.g., data mining), information access and dissemination, and information integration (e.g., decision support in business) (Fox and Mills, 1994). The problem of information access and dissemination forms the framework for NPAC's InfoVision program. InfoVision stands for **I**nformation, **V**ideo, **I**magery, and **S**imulation on demand (Mills et al., 1994).

NPAC currently has a set of projects underway for developing InfoVision applications (e.g., financial simulation, credit card data mining, multimedia kiosks, community information systems, movies on demand, text retrieval) and technologies (e.g., parallel databases, networking hardware and software, user interfaces, image processing). InfoVision may be considered a prototype of the NII, with the Living Textbook project as an InfoVision application in education.

As noted above, the tremendous performance improvements in computing and telecommunications make the NII possible. The future NII promises to deliver a high speed (10 megabits/second) interactive link to some 100 million desktops in our homes, offices, and schools. Our InfoVision model of information access and dissemination links by high speed network a data rich, central Infoserver environment (most likely a hierarchy of servers) with a relatively computing rich but data poor home, office, and school computing environment.

A home technology push is an important aspect of developing the NII. Information technology products such as virtual reality peripherals, CD-ROMs, powerful personal computers, and large disks must be mass produced for the consumer market in order for them to become cheap enough to be universally available. Equal access to the NII, especially in educational settings is a very important policy issue.

Information on Demand in Education

Our short term technological goals include a set of prototype multimedia information on demand applications based on NPAC's computing facilities and delivered over NYNET to the three upstate schools in the project. These demonstrations feature:

- Video on Demand: a video library of approximately 100 hours of VHS quality material, this video material will be searchable by online text indices, and available on demand over the NYNET network. Potential sources of video material include large industry content providers such as Reuters News Service, as well as dozens of community based organizations such as museums, local television stations, and the public library system. Figure (3) illustrates NPAC's World Wide Web server (http://www.npac.syr.edu) and the visit of First Lady Hillary Clinton to NPAC's video on demand laboratory. Figure (4) a prototype video on demand application based on CNN Newsource video clips. A searchable text index accompanies the digital video clips.
- New York State–the Interactive Journey: an interactive journey of New York State geography with links to spatially located multimedia databases. For example, a student could navigate the Adirondack Mountain region in a real time terrain rendering environment, stop at Lake Placid, and view video, image, and text databases describing the 1980 Olympic Games, or navigate the lake plain region of Western New York and video footage of Niagara Falls. Figure (5) illustrates the Living Textbook web page (included in NPAC's web page under research projects in education) and a representation of the terrain, map information, and images in the interactive journey.
- Collaboration technology for teaching and learning: based on a related telemedicine project for linking rural health care facilities with university hospital medical specialists. Collaboration technologies provide interactive multimedia communications, with shared databases. Figure (6) illustrates how a university based surgeon in Syracuse might share a medical consultation with an Ogdensburg based general practitioner.
- a set of related educational applications such as a network based "text on demand" application for searching AskERIC's online database (Figure 7), foreign language teaching programs, network distribution of multimedia materials from educational publishing houses, scientific simulations of Grand Challenge applications such as a tornado forecast model modified for teaching science illustrated in Figure (8).

Summary

We are in the first month of a multi-year project to deliver innovative, multimedia educational software applications in a high performance computing and communications environment. The NYNET wide area gigabit testbed network is among the first such networks connected to K-12 schools. We have a unique opportunity to develop state of the art applications in education and to demonstrate some of the future possibilities of connecting classrooms to the NII.

We will use our InfoMall partnership model of combining enabling technologies, technological and educational expertise, and state of the art facilities to develop the Living Textbook project. We propose our set of InfoVision information on demand applications and technologies as a prototype of the future NII, with the Living Textbook as a leading example of InfoVision applied to education.

The client/server model of InfoVision is ideally suited to delivering digital information services over high speed networks from centralized information servers. We expect that this model is well suited to teaching and learning approaches based on a two-way interactive information flow supporting bottom up learning and innovation rather than top down teaching.

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